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GRADING AND SIZING APPLES WITH BRUSHES

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

PREFACE

This research was performed under the general supervision of Joseph F. Herrick, Jr., Investigations Leader, Handling and Facilities Research Branch, TFRD, ARS. The prototype experimental equipment was built by the Wells and Wade Co., Wenatchee, Wash., under contract with the U.S. Department of Agriculture. The prototype has been installed in the packinghouse of the Krispy "K" Fruit Co., Monitor, Wash., for testing under full operating conditions.

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GRADING AND SIZING APPLES WITH BRUSHES

by

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INTRODUCTION

One of the needs of fruit packers in the Pacific Northwest and other areas is equipment that will permit grading, brushing, and sizing of fruit with a minimum of damage. This equipment should handle apples, pears, and peaches equally well, be gentle enough to permit the additional handling required in a prestorage grading operation, provide for accurate grading and sizing, include brushing and polishing, and maintain a volume at least equal to that of existing equipment.

The greatest damage to apples during grading, brushing, and sizing occurs at those points where apples transfer from one piece of equipment to another. Where length of fall is minimized and proper padding is used, no single transfer point is likely to cause serious bruising; but the large number of transfers necessary causes almost every fruit to receive some small indentations. At the time they occur, these indentations may not be noticeable. However, over a period of time they become manifest as small pits, bruises, or blemishes on the surface of the fruit, and they affect the fruit's marketability and grade.

It was primarily to overcome the damage caused by transfers of fruit on existing grading and sizing equipment that the unitized brush-sizer was designed.

The unitized brush-sizer represents a new concept in fruit grading and sizing. Grading, polishing, and sizing are all performed on brushes, without transferring the fruit from one piece of equipment to another. Although the unitized brush-sizer was designed primarily for tender Golden Delicious apples, the concept may be applicable to other fruits and vegetables as well.

A small-scale laboratory mockup of the equipment was assembled and tested by Department of Agriculture research personnel, and a prototype was then constructed by a contractor. This report describes the prototype equipment and the tests made with the laboratory mockup.

ADVANTAGES OF THE UNITIZED BRUSH-SIZER

The unitized brush-sizer is expected to provide the following advantages over existing methods and equipment for grading, brushing, and sizing apples and certain other fruits:

1. Fruit is sorted into grades, brushed, and sized on a single item of equipment and in one continuous operation, without having to be transferred to different equipment components.
2. While being sorted, brushed, and sized, the fruit is nestled between two soft brushes for maximum protection against bruising. This arrangement eliminates the bumping of one fruit against another.
3. The rollers of the elevator that moves apples from the water tank at the head of the packing line are of soft polyurethane. This material minimizes bruising and provides a means for partially drying the fruit by absorption before moving it onto the brushes.
4. Sorting is performed before the apples are brushed, so that rotten fruit is removed immediately. The sorting section is divided into lanes, with each sorter responsible for one lane. Fruits move past the sorters in a straight line, at precisely 5 1/4-inch intervals. Previous research has shown that greater sorter productivity is achieved when lanes are used, and it is possible that an orderly presentation of the fruit will increase sorter efficiency even further. ^{1/}
5. Fruit that is on the borderline between two grades is placed on an overhead shelf. Grade decisions on this fruit are made during periods when the line is not running, and there is more time to evaluate the fruit, or the grade decisions are made by the head sorter. This arrangement should permit faster grading of the more obvious quality fruit, and better grading of the hard-to-grade fruit.
6. The unitized brush-sizer simultaneously sizes two grades of fruit and delivers them to separate packing lines. With existing equipment, an additional sizer must be installed to size the second grade of fruit.

^{1/} Hunter, D. Loyd, Kafer, Francis, and Meyer, Charles H. Apple Sorting Methods and Equipment. U.S. Dept. Agr. Mktg. Res. Rpt. No. 230, 24 pp., illus. 1958.

7. The rate and direction of rotation of the brushes for each of the three sections (sorting, brushing, sizing) can be varied over a wide range. By varying the rate of rotation of the brushes in the sorting section, optimum rate of apple rotation can be maintained, even though size or variety of fruit changes. Brushing requirements of different lots and varieties vary, but with existing equipment these rotational rates are set and are not adjustable.
8. On the return portion of each cycle the brushes travel through a cleaning and disinfecting tank and then through a rinse tank. This prevents the buildup of dirt and wax and reduces the spread of rot-causing organisms. After cleaning and after rinsing, brushes are spin-dried to remove excess water. With present equipment there is no way to clean or de-wax brushes while they are in use. Thus, a rotten apple going across the brushes leaves a trail of inoculum for apples that follow. Also, wax can build up on brushes to the point where wax "hammers" on the bristle tips inflict injuries on the fruit.
9. The unitized brush-sizer is expected to handle pears and peaches as well as apples. It may also find application with other fruits and vegetables.
10. The unitized brush-sizer is easily adaptable to existing dumpers, float tanks, chemical applicators, and packing and filling equipment, and it occupies considerably less floor area than existing grading and sizing lines.

DESIGN OF THE UNITIZED BRUSH-SIZER

Apples, being nonsymmetrical, do not roll in any established manner. Rather, some roll quickly down a ramp, some slowly, some roll straight down, and some roll diagonally. As they make their way down a transfer ramp, apples often bump against each other or fall onto other apples as they leave the ramp.

The first consideration in designing new equipment was to reduce the number of transfer points between equipment components. Other objectives were to provide for efficient sorting, effective brushing, and accurate sizing. Also, the volume handled and the labor productivity had to be at least comparable to volume and labor productivity with existing equipment.

How the number of transfer points was reduced in the new design is illustrated in figure 1. A representative existing grading line (A) transfers fruits nine times from the elevator to the sizer: (1) Elevator to ramp, (2) ramp to eliminator, (3) eliminator to ramp, (4) ramp to brushes, (5) brushes to ramp, (6) ramp to sorting table, (7) sorting table to ramp, (8) ramp to singulator, (9) singulator to sizer. The unitized brush-sizer (B) transfers fruits only once (elevator to brushes), and during this transfer the fruits are prevented from touching each other.

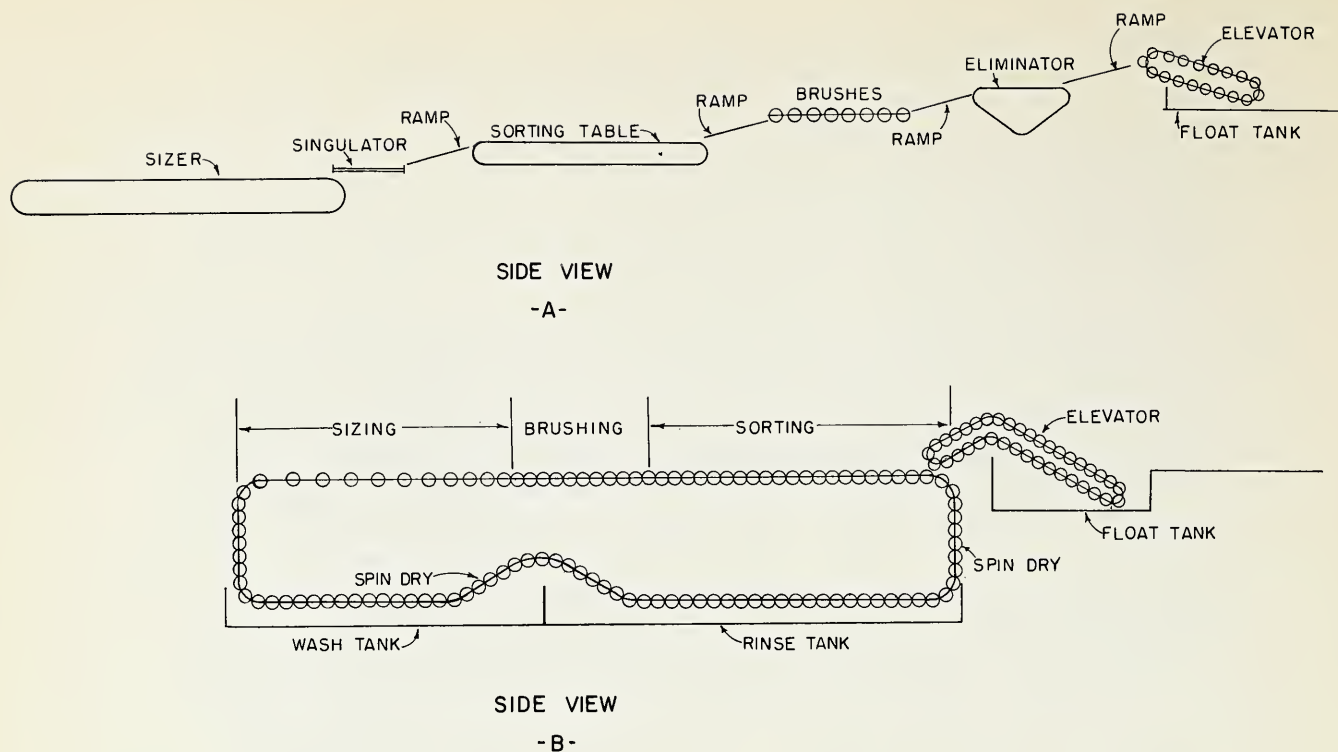


Figure 1.--Schematic side view drawings of typical grader used in Pacific Northwest (A), and experimental unitized brush-sizer (B).

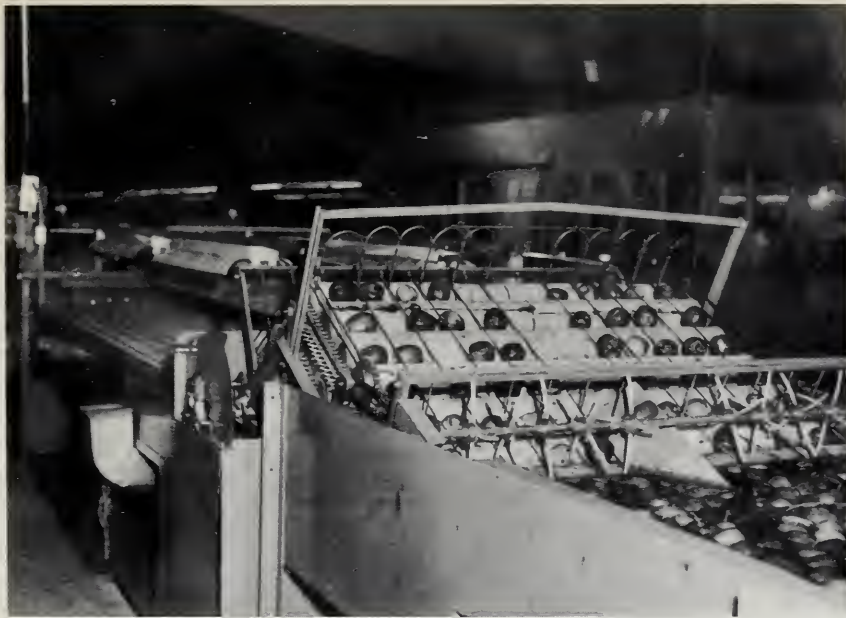
The brushes of the unitized brush-sizer are perpendicular to the line of travel of the apples through the sorting, brushing and sizing operations. During the operations, apples remain on the pair of brushes they are transferred to from the elevator. The brushes move in a continuous cycle through these operations and through washing and rinsing tanks.

The brushes are 0.015-inch diameter polyethylene fibers extending 1 1/2 inches from the core, full-wrapped (alternately left and right hand) on a 2-inch core. Their overall length is 48 inches.

The submersion dumper and float tank used with the unitized brush-sizer are the same as those generally found in the Pacific Northwest.

Elevator

The elevator consists of a series of 4-foot long, 4 3/4-inch diameter polyurethane rollers spaced 6 inches on center (fig. 2). This leaves a gap of 1 1/4 inches between rollers. Trash and very small fruit fall between rollers into water and are carried to one side and removed. As rollers rise out of the float tank they pass over a grid which squeezes out water that has been absorbed both in the tank and from the fruit. The rollers lose water on the bottom side and are able to absorb water from the fruit on the top side. This provides some drying of the fruit.



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Figure 2.-- Elevating rollers carry apples from flotation tank to brushes.

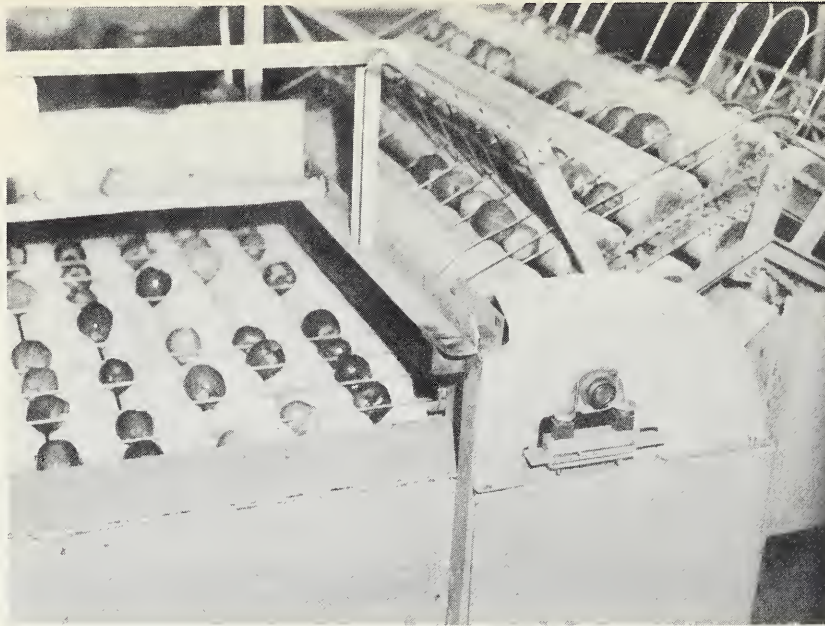
Apples in tank are kept crowded against rollers by circulation of water in the tank, and are boosted into space between rollers by fingers projecting from slowly turning shaft. Lanes over elevating rollers correspond with lanes over sorting section.

Lane formers divide the elevator into 10 lanes, 5 on each side, with fruit restricted from the center 8 inches. A "rotating finger" prevents apples from bridging across lanes and helps them gain their position between the elevator rollers.

At the head of the sorting section apples fall from the elevator to a position between two brushes (fig. 3). The elevator and the brushes are synchronized so that a pair of brushes is always in position to receive fruit as it is delivered from the elevator. At the time they receive fruit from the elevating rollers, the brushes are already rotating.

Sorting

In the sorting section, the brushes rotate in reverse direction from the flow of fruit and the rate of rotation is variable, so that it is possible to make the apples rotate both in a forward direction and at a predetermined rate. This assures sorters fullest possible visibility of each fruit.



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Figure 3.--Apples are delivered from elevating rollers (right) to sorting section (left). Apples are kept in lanes for sorting.

The sorting section, like the elevator, is divided into 10 lanes--5 on each side. The center 8 inches is reserved for the second grade. Each sorter is responsible for the fruit in only one lane. The sorter grades the rotating apples as they are carried past the work station. The predominating grade of fruit is left in the lane; the second grade is removed and placed in the center section; cull apples are placed in cull chutes alongside each sorting station; and any apple whose grade is borderline or difficult to determine is removed and placed on the padded shelf over the center section.

Later, when the line is not running or when time is available, the sorter can take more time to grade the fruit placed on the shelf; or the head sorter can inspect the fruit on the shelf periodically and make these more difficult grading decisions. In the latter case, the head sorter could learn what was causing difficulties in sorting and could counsel the sorters.

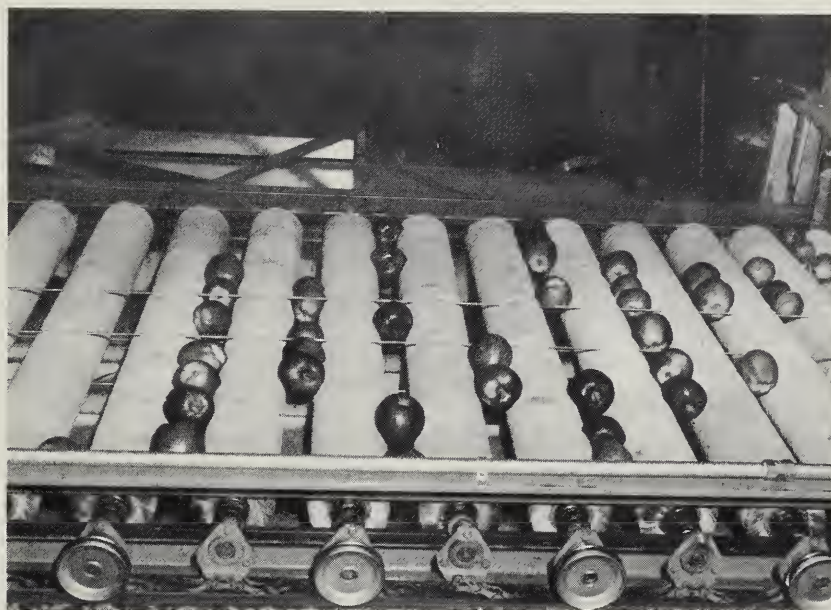
Brushing

The brushing section is an extension of the sorting section, but the sorting lane dividers do not extend into the brushing section, and the brushes rotate at a different rate. To achieve a wiping action on the apples it is necessary to rotate alternate brushes at different speeds. One set rotates at a relatively low speed, and the other set at a relatively high speed. These two rates are independently controllable over a wide range.

If a brushing action is not desired, the rotational rates of the brushes in the brushing section can be adjusted to correspond with the rotational rate in the sorting section. With this done, the brushing section becomes only a means of transporting fruit from the sorting to the sizing section.

Sizing

After brushing, apples enter the sizing section. Sizing is accomplished as the brushes gradually spread apart over the length of this section, while at the same time rotating at the optimum rate for the particular fruit variety (about 120 r.p.m. for Delicious) (fig. 4). Apples tend to aline themselves



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Figure 4.--Sizing section begins at extreme right. The gaps between the brushes gradually widen from beginning to end of this section so that small apples drop through first and large apples last.

along the same axis (the stem-calyx axis with Delicious), so that the great majority of fruits are measured along the same axis. As the brushes move forward and separate, the apples settle deeper into the troughs formed by the brushes. When the weight of an apple overcomes the ability of the brushes to hold it up, the apple drops through. The place at which it drops through determines its size classification. Small apples drop through first, and large apples last.

The unitized brush-sizer was designed to separate fruit into eight sizes. If more sizes are desired, the sizing section can be made longer; for fewer sizes it can be shortened. The brushes must travel at least 15 inches for each size division.

When an apple drops through the brushes it falls on a padded, sloping transfer unit. The apple rolls down the transfer unit onto a 4-inch wide take-away conveyor belt which delivers the fruit to a distributor belt; this in turn delivers the fruit to a return-flow belt for packing.

There is one transfer unit, consisting of three sections, for each fruit size (fig. 5). The transfer units under the sizing section are so arranged

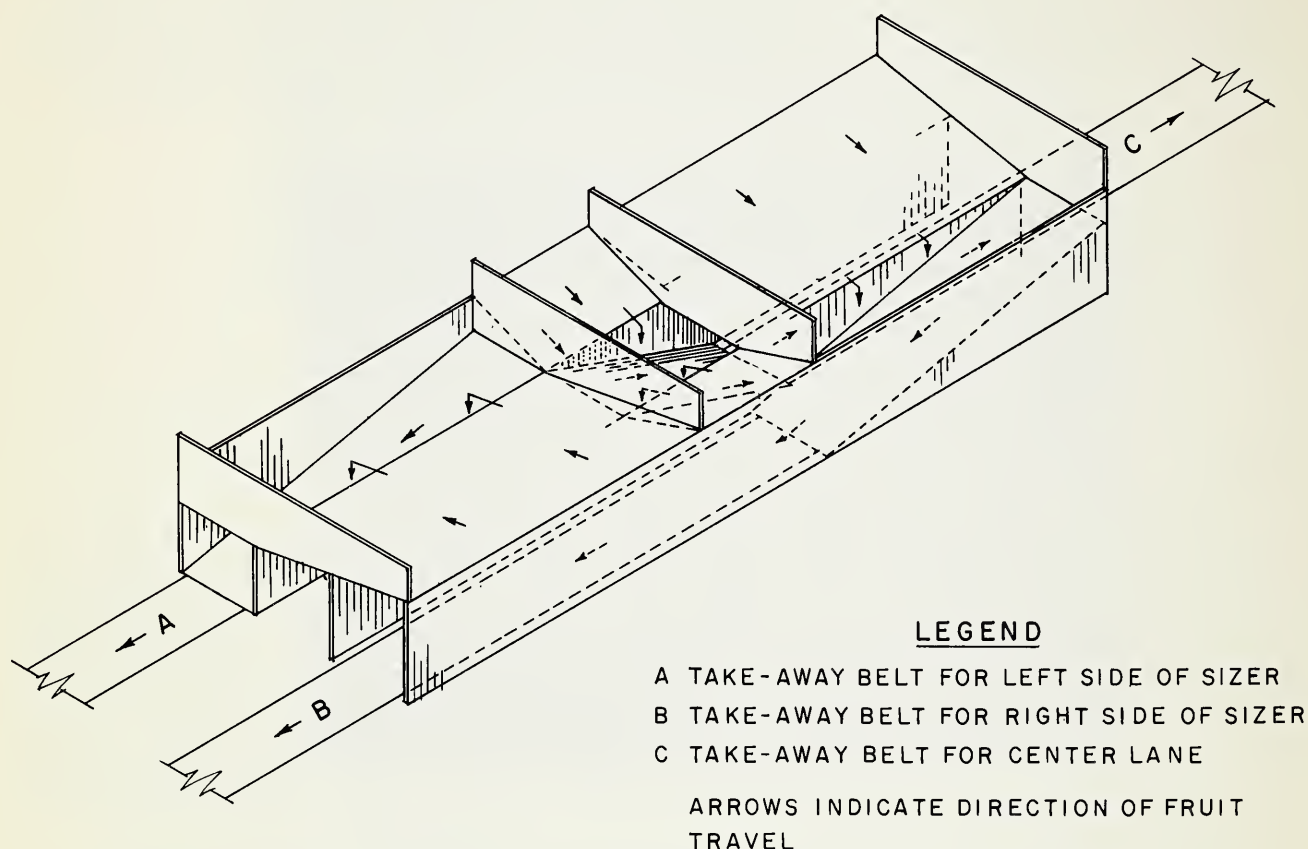


Figure 5.--Transfer unit for gently transferring fruit from sizer sections to takeaway belts.

that one grade of fruit is delivered to one return-flow belt, and the other grade to the other belt. The transfer units prevent fruit from falling onto other fruit, which is a common problem with present sizing methods. Apples from the left side of the unitized brush-sizer are delivered to takeaway belt A, and apples from the right side are delivered to takeaway belt B. Takeaway belts A and B deliver apples to the same distributor belt. The fruit from the center lane, the second grade, is delivered to takeaway belt C and carried to a second distributor belt.

Test runs with the sizing section showed that apples would not always roll down the transfer unit onto a takeaway belt. When this happened, apples would pile up, forming a logjam of fruit. To assure that all apples would roll freely on the transfer units, a device for vibrating the units was designed.

Upon reaching the end of the sizing section, the brushes begin their return to the head of the unitized brush-sizer.

Cleaning the Brushes

On the return portion of their cycle, the brushes travel through a cleaning tank where dirt and wax are removed and rot-causing organisms are destroyed. This tank holds 225 gallons and is located directly under the sizing section (see fig. 1). After traveling through this tank, the brushes are carried upward and rotated rapidly so that a spin-dry effect is achieved. Any discharge is directed back into the cleaning tank. After spin-drying, the brushes are lowered into a rinse tank, where any residual chemicals are rinsed off. This tank holds 300 gallons and is located directly under the brushing and sorting sections. The brushes are spin-dried once again as they are lifted out of the rinse tank. This leaves them in condition to receive fruit as they are carried up to a position under the elevating conveyor.

PACKING SYSTEM

Two packing lines are used with the unitized brush-sizer--one for each grade of fruit. The packing lines are return-flow belts, with power shunts for the predominant-grade line and nonpowered shunts for the other. A layout is shown in figure 6. Shunts confine fruit of a common size to that section of a return-flow belt allotted to their size. Both powered and nonpowered shunts are used so that an evaluation can be made of their relative merits.

Each packing line is divided into eight sections--one for each fruit size. It is possible, by moving the shunts, to reduce a section to as little as 2 feet of belt space or to enlarge it to as much as 18 feet. With this capability, management can compensate for runs of fruit having a predominance of one or two sizes. By expanding the space allotted to the predominant sizes (by reducing the space allotted to the small-volume sizes), management can assign packers to those sections where they are most needed. Such flexibility provides a valuable management tool.

A return-flow belt system is shown here, but there is no reason why the fruit could not be delivered to tubs or tables as well.

Figure 7 shows the packing system set up in a commercial apple packing room.

RESULTS OF PRELIMINARY TESTS

The first work done to test the feasibility of the brush-sizer concept was with a small-scale mockup model under laboratory conditions. The mockup consisted of two short lengths of brushes mounted in a frame in such a way that the brushes could be both rotated and separated.

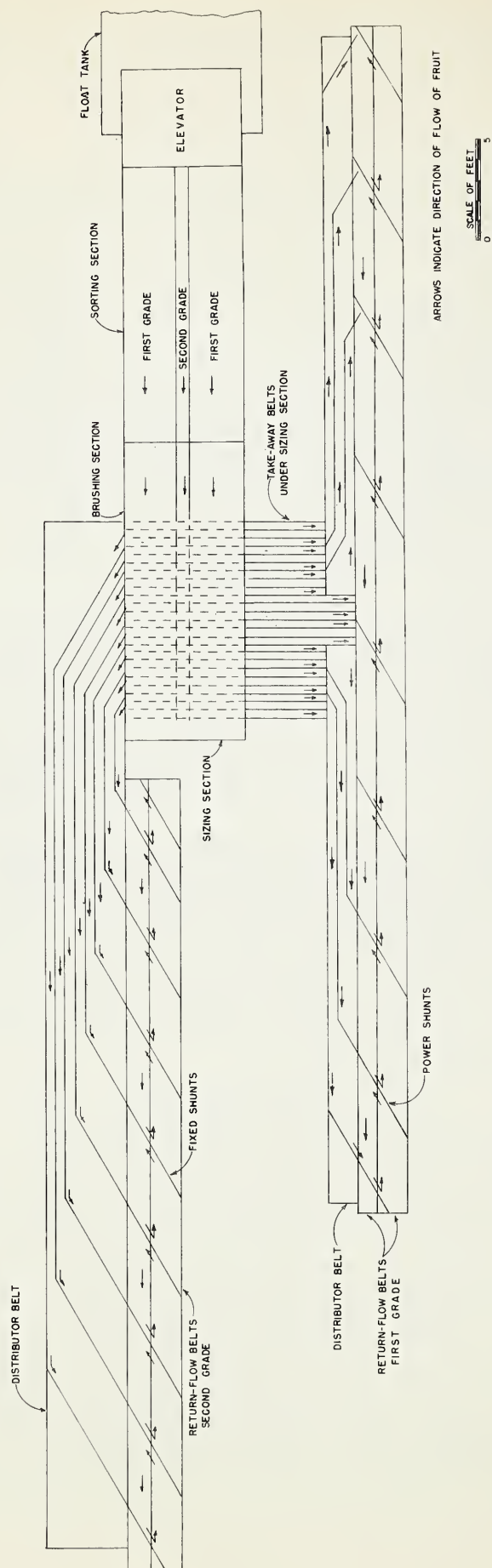
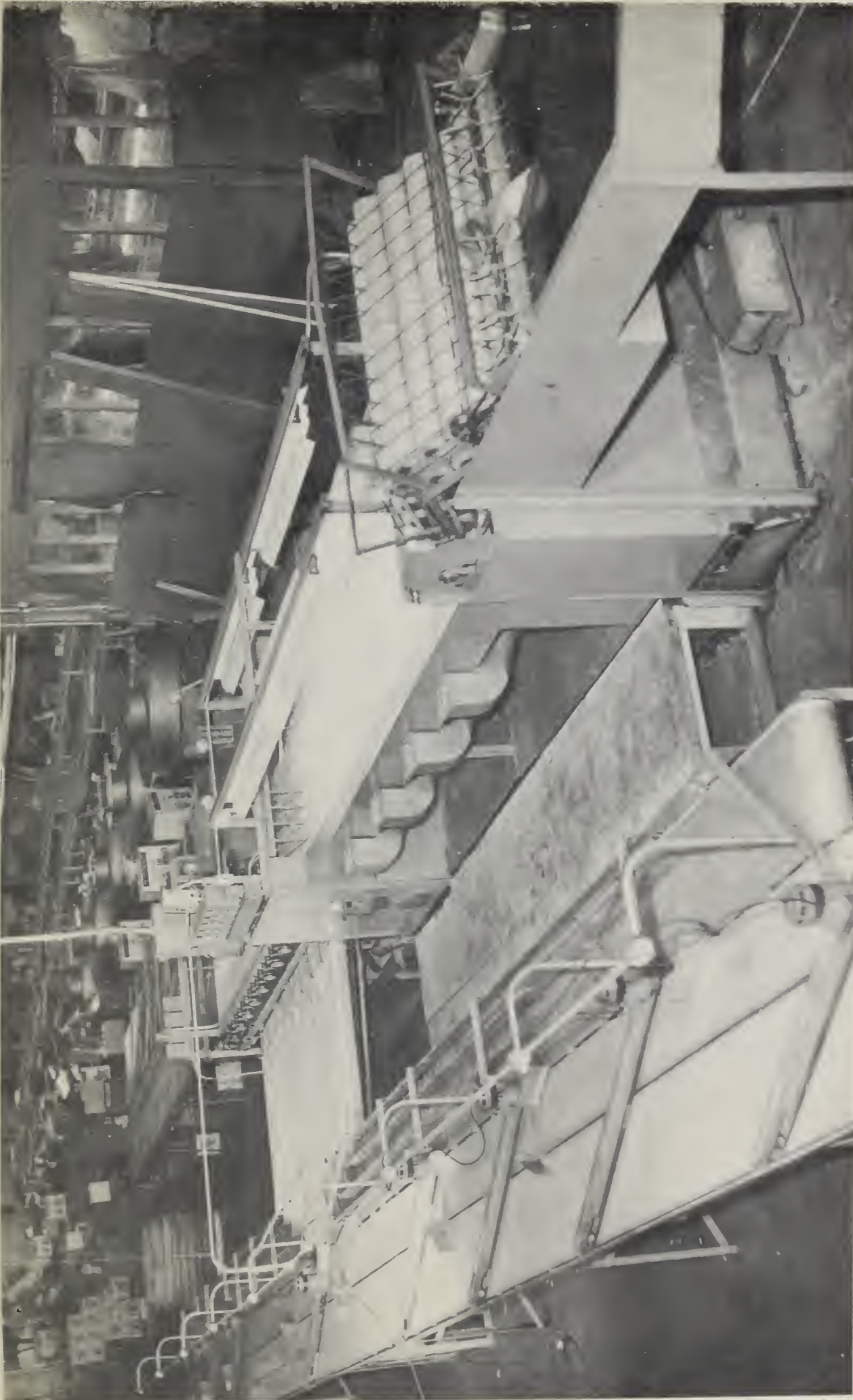


Figure 6.--Layout of packing line employing experimental unitized brush-size.



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Figure 7.--The unitized brush-sizer is on the right, the return-flow belt packing line for the major grade fruit is on the left, and the packing line for the minor grade fruit is to the rear of the unitized brush-sizer.

Bruising

Apples were manually dropped into the trough formed by the rotating brushes. At the rotational rates that will be used with the full-scale prototype, and at a drop height greater than that which will actually be necessary, no discernible damage occurred--even with the Golden Delicious variety. The hundreds of flexible fibers making up the brushes absorb the force of an apple's fall, and provide a cushion for the apple for the entire time it is on the unitized brush-sizer.

Sizing

To test the feasibility of sizing apples on rotating brushes, the mockup sizer and presized apples were used. Several different rotational rates were tried, with about 120 r.p.m. giving the best results.

All apple sizes from 180 to 56 were included in the tests. Several boxes of field-run apples were manually sized, and the size was marked on each fruit. With the brushes rotating, these apples were set between the brushes, and then, through a cranking arrangement, the brushes were made to separate. At the instant the fruit fell through, the gap between brushes was noted and recorded. Several hundred apples were tested in this manner.

Data recorded during sizing tests indicate that, for the Delicious variety, 85 percent were sized within a range of 1/8-inch diameter (plus or minus 1/16-inch from the mean), and 98 percent were within a range of 1/4-inch diameter (plus or minus 1/8-inch from the mean). While this is sizing of a very high order, it still must be determined if these results can be obtained with the full-scale model over full-production runs.

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